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World food and agriculture: Outlook for the medium and longer term

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ABSTRACT The world has been making progress in improving food security, as measured by the per person availability of food for direct human consumption. However, progress has been very uneven, and many developing countries have failed to participate in such progress. In some countries, the food security situation is today worse than 20 years ago. The persistence of food insecurity does not reflect so much a lack of capacity of the world as a whole to increase food production to whatever level would be required for everyone to have consumption levels assuring satisfactory nutrition. The world already produces sufficient food. The undernourished and the food-insecure persons are in these conditions because they are poor in terms of income with which to purchase food or in terms of access to agricultural resources, education, technology, infrastructure, credit, etc., to produce their own food. Economic development failures account for the persistence of poverty and food insecurity. In the majority of countries with severe food-security problems, the greatest part of the poor and food-insecure population depend greatly on local agriculture for a living. In such cases, development failures are often tantamount to failures of agricultural development. Development of agriculture is seen as the first crucial step toward broader development, reduction of poverty and food insecurity, and eventually freedom from excessive economic dependence on poor agricultural resources. Projections indicate that progress would continue, but at a pace and pattern that would be insufficient for the incidence of undernutrition to be reduced significantly in the medium-term future. As in the past, world agricultural production is likely to keep up with, and perhaps tend to exceed, the growth of the effective demand for food. The problem will continue to be one of persistence of poverty, leading to growth of the effective demand for food on the part of the poor that would fall short of that required for them to attain levels of consumption compatible with freedom from undernutrition.

Key Historical Developments

Improvements in Food Supplies. In the last three decades, the world as a whole has made significant progress in the food and nutrition area. Progress is measured in terms of the per person availability of food products for direct human consumption as a national average in each country, expressed in kcal/day. This is an admittedly imperfect yardstick. However, it comes much closer to what we need to measure and monitor—the degree of satisfaction of human food needs—than the commonly used measure of gross production of food commodities per person. Gross production ignores postharvest losses and all uses of food commodities other than for direct human consumption, e.g., for seed, animal feed, and ethanol production (from maize in the USA and sugar cane in Brazil).*

By accounting fully for food imports and exports, per person availability makes possible the monitoring of changes in the apparent food consumption of individual countries, which the production statistics alone cannot do.

As a world average, the per person food availability for direct human consumption grew 19% to 2,720 kcal/day (1 kcal = 4.18 kJ) in the 35 years to the 3-year average 1994–1996, whereas that of the developing countries grew 32% to 2,580 kcal/day.† Meanwhile, world population grew from 3.0 billion in 1960 to 5.7 billion in 1995. Naturally, world averages have limited value for tracking changes in the welfare of persons (see below). Use of the national averages of individual countries makes possible the analysis of intercountry distribution of gains. As such, the national averages provide a better, although far from satisfactory, basis for tracking such changes. They show that the part of world population living in countries where per person food supplies are still very low (under 2,200 kcal/day) decreased considerably to only 10% in the mid-1990s, down from 56% 30 years earlier. At the other extreme, 60% of the world’s population now lives in countries with per person food supplies over 2,700 kcal/day, up from 30% 30 years ago. China, with its huge population and rapid economic and agricultural growth after the late 1970s, accounts for a significant part of this massive upgrading in the food availability of the developing world.

Excluding China, the gains of the developing countries have been much less impressive, 22% rather than 32%. The detailed country-level data indicate that progress has been very uneven and has bypassed a large number of countries and population groups. Many countries in sub-Saharan Africa and South Asia and assorted countries in other regions either made little progress or suffered outright declines from levels that were grossly inadequate for good nutrition to start with. Thus, sub-Saharan Africa still has food availability of only 2,150 kcal/day, compared with 2,050 kcal 30 years earlier. The comparable figures for South Asia are 2,350 kcal and 2,000 kcal, respectively. The per person food availabilities of the other developing regions (Latin America/Caribbean, East and Southeast Asia, and Near East and North Africa) are in the range 2,700–3,000 kcal, whereas those of Western Europe and

*It is, however, inclusive of post-retail waste and nonfood uses at the household level, e.g., food fed to pets—hence the very high levels of food availability generally found in the statistics of many high-income countries, often over 3,500 kcal-person⁻¹·day⁻¹.

†The term *developing countries* comprises all of the countries of the world except those of Europe (both east and west) and North America, all the countries of the former U.S.S.R., Japan, Australia, New Zealand, the Republic of South Africa, and Israel. This classification reflects, above all, traditional practice and is useful for historical comparisons. However, it leaves much to be desired when it comes to grouping countries by levels of development currently prevailing, a problem that has been intensified in recent years with the new low-income countries created in the wake of the collapse of many economies formerly centrally planned.

North America are 3,370 kcal and 3,570 kcal, respectively (see footnote[†]).

The extremely low levels of food availability still prevalent in several developing countries imply that undernutrition is widespread. It is estimated that there are currently over 800 million persons undernourished in the developing countries, with high concentrations in South Asia and sub-Saharan Africa (1). Progress in reducing these numbers has been painfully slow, with reductions in East Asia being compensated to a large extent by increases in sub-Saharan Africa.

The Role of Food Trade. The bulk of the increases in the consumption of the developing countries was met by increases in their own production. In the case of cereals, their production grew at 3.0% per annum (p.a.) in the 3 decades to the mid-1990s and provided 87% of the increase in their consumption. However, in a considerable number of countries, gains in food availability depended to a significant degree on rising food imports, particularly during the 1970s. In that decade, the net imports of cereals of the developing countries as a whole tripled, following the growth of incomes and foreign exchange earnings of the oil exporters, as well as the conditions of easy foreign borrowing and debt accumulation of other countries. For example, in North Africa, the per person consumption of cereals (all uses) increased from 232 kg in the mid-1960s to 322 kg in the mid-1980s, and per person net imports skyrocketed from 44 kg to 167 kg in the same period. North Africa's cereals self-sufficiency (production as percentage of consumption) fell from 76% to 51% in the 2 decades to the mid-1980s and has remained in the range 50–55% in subsequent years. Many other countries experienced similar precipitous declines in their self-sufficiency associated with improvements in consumption over the same period, e.g., Saudi Arabia, Republic of Korea, Taiwan Province of China, Congo, and Gabon.

Not all developing countries went through this experience of growing dependence on imports, certainly not the largest ones. The two most populous countries of the world, China and India, illustrate this point. China, widely discussed in recent years as a potential source of huge increases in import demand in the future (2, 3), had net imports of cereals exceeding 5% of its aggregate consumption only in exceptional years during the period of quantum gains in its domestic demand. More often it was close to 100% self-sufficiency, and China was an occasional net exporter. India, which depended on cereal imports for a crucial 14% of its consumption 30 years ago and was widely believed to be on a path of growing dependence on such imports, became virtually 100% self-sufficient and indeed an occasional net exporter. India's apparent consumption of cereals grew at about the same rate as that of China (2.8–2.9% p.a. in the 20 years to 1996), but its gains in per person consumption have been much more modest than those of China, and undernutrition remains widespread. India had started with much lower levels of per person consumption and also had a higher population growth rate than China (2.1% p.a. compared with 1.4% p.a.). Obviously, India's path of declining dependence on food imports reflected not only the production gains from the green revolution but also the little headway made in reducing poverty and the consequent inadequate growth in the effective demand. Had India achieved gains in per person consumption comparable to those of China, it is an open question whether it would have achieved nearly 100% self-sufficiency. More generally, avoidance of drastic declines in self-sufficiency by the many countries that still have very low levels of consumption often reflects not so much success in their agriculture but rather failure to make sufficient progress toward raising consumption levels to nutritionally satisfactory levels.

In conclusion, food imports played an important role in making possible the quantum jumps in consumption of numerous developing countries that could pay for such imports, although the behavior of the very large countries contributed

to avoiding large declines in the cereals self-sufficiency of the developing world as a whole. The latter declined from 95% in the mid-1960s to 93% in the mid-1980s and to 90% by the mid-1990s. By about the early 1980s, the era of rapid import growth of the developing countries had come to an end and their net imports moved in the range 70–110 million tons in the subsequent years to the present. These developments notwithstanding, the possibility that there might be further spurts in their import demand is an issue that remained very much alive. It reflects perceptions that there is now much less scope than in the past for further production gains from the green revolution, while sustained economic growth may lift significant numbers of people out of poverty and boost demand at rates high enough to cause a significant part of it to appear as solvable demand for imports (4). From here, it is a short step to worry about the capability of the rest of the world to increase production and generate the necessary export surplus. What does the historical evidence show?

By and large, the traditional cereal exporters (North America, Argentina, Australia, and in more recent years, also Western Europe) coped quite well with spurts in import demand. Between themselves, they export currently (average 1994/96) some 160 million tons of cereals net annually.[‡] This is just over 3 times their net exports of 30 years earlier. About one half of the total increment in these net exports was contributed by Western Europe. It is a very significant development for the world food system that this region turned from a net importer of 27 million tons in the mid-1960s to a net exporter by the early 1980s and was exporting 21 million tons net in the mid-1990s. In practice, the other, more traditional, exporters have had (or, perhaps one should say, were constrained by Western Europe's policies) to increase their net export surplus rather modestly, from 77 million tons in the mid-1960s to about 138 million tons 30 years later. Had Western Europe remained a net importer of 27 million tons, the more traditional exporters would have had to increase their net export surplus to 185 million tons.

We do not have a counterfactual scenario to answer the question of how the different variables of the world food system (in particular the per person food availability of the poor countries and those that became heavy importers) would have actually fared if Western Europe had not followed a policy of heavy support and protection of its agriculture. Such policy led to the region's import substitution and then subsidized exports, all accompanied by polemics and friction in the trade policy area. The resulting lower and more volatile world market prices (compared with what they would have been otherwise) are thought to have adversely affected the food security of the developing countries because of the negative effects on the incentives to their producers. However, the positive effects on the consumption of the poor of the lower import prices and increased availability of food aid must also be taken into account when evaluating the impacts of such policies on food security. In the end, such policies of Western Europe resulted in the emergence of an additional major source of cereal export surpluses to the world markets and diversified the sources from which the importing countries could provision themselves. This is a structural change that is probably here to stay even under the more liberal trade policy reforms of recent years and the further ones to come (5).

Slowdown in World Agricultural Growth. In the 1990s, there has been a slowdown in the growth of world agricultural production. World cereals output stagnated and fluctuated widely in the first half of the decade. In per person terms, it fell from the peak of 342 kg achieved in the mid-1980s to a low of 311 kg in the 3-year average 1993–1995, before recovering to

[‡]One hundred eighteen to the developing countries other than Argentina, 33 to Japan and Israel, and 6 to the area former U.S.S.R./Eastern Europe.

323 kg in the latest 3-year average 1996–1998. In parallel, production of capture fisheries seems to have hit a ceiling of just over 90 million tons, and much of the increase in fish production is coming from aquaculture, a development likely to continue in the future. In the face of these developments, it would appear that the world food situation has been worsening. However, the evidence we presented earlier points in the opposite direction. As noted, world average indicators have limited value for welfare analysis, and the variables must be observed at a more disaggregated level for a correct interpretation. Progress in food security need not manifest itself in rising world averages (i.e., with aggregate production or consumption rising faster than world population), but it is possible for progress to occur when the world average stagnates or even falls.⁸ Thus, in the 10 years to the mid-1990s that witnessed the declines in the world averages, there has been no decline, but rather an increase, in the per person production and consumption of cereals in the developing countries, whereas that of all other food products (roots and tubers, pulses, bananas and plantains, livestock, sugar, oilseeds, fruit and vegetables, etc.) grew even faster than in the preceding 10 years. The problem for the developing countries remains one of too low production and consumption per person.

The declines in world cereals output per person have been interpreted by some as beginning an era when the natural resource and technology constraints have become all of a sudden so much more binding (6). In reality, this slowdown has been due, in the first place and up to quite recently, to policy reforms and supply controls coinciding with weather shocks in the main industrial exporting countries.⁹ The longer term deceleration in the growth rate of cereals production in these countries has reflected, above all, the inadequate growth of demand (both domestic and external) for their produce and the associated decline in real prices. For example, the real price of wheat in constant 1990 U.S. dollars per metric ton was in the range of U.S. \$200–240 (annual averages) in the first half of the 1980s and in the range of U.S. \$125–150 in the following 10 years to 1995. For maize, the ranges were U.S. \$150–200 and U.S. \$85–105, respectively (ref. 7 and previous issues). In more recent years, the decline reflected also the collapse of production (as well as of consumption and net imports) in the countries of Eastern Europe and the former U.S.S.R. following the drastic systemic reforms in their economies. Although recovery may be long in coming, the collapse of agriculture in this group of countries will likely prove to be a transient phenomenon. What may prove to be a more enduring structural change in the world food system is the impact of policy

reforms, in part linked to the new policy environment for international trade. These reforms may lead to the cessation of generation of quasi-permanent structural surpluses and the holding of large stocks in the major exporting countries by the public sector, which in the past were readily available for interventions in case of abrupt shortfalls in supplies.

World Production and Food Insecurity: An Uncertain Link.

The preceding discussion indicates that, by and large, the production system of the world as a whole has been generating food supplies at a rate which was more than sufficient to meet the growth of effective demand. The evidence is the secular declining trend of the real price of food in world markets (8). It is equally true that food insecurity and undernutrition have persisted at high levels. The combination of these two facts certainly suggests that undernutrition is not because of a lack of global capability to produce the additional food required to eliminate undernutrition, which is a very small amount (2–3%) compared with current or future world food output (9).

It is now widely accepted, if there ever was any doubt, that food insecurity and undernutrition are above all caused by the persistence of abject poverty, development failures (often linked to war and unsettled political conditions), and lack of appropriate social policies. This, however, does not absolve us from the need to address the question of the links between food production and the food welfare status of the population, particularly of those countries and population groups with very inadequate consumption levels. Obviously, a *prima facie* case can be made that such links exist when production failures, particularly where they are endemic, are somehow a causal factor in overall development failures and the perpetuation of poverty. In such cases, it is quite legitimate to hold that persistence of undernutrition is due, at least in part, to inadequate growth of production.

Such a statement may not apply to the world as whole but it would be certainly valid in the socioeconomic and natural resource environments in which production failures (or more generally failure to develop agriculture), poverty and undernutrition coexist. Such a link is indeed present in the many low-income countries with high dependence on agriculture (50–80% of the population depending on agriculture as the main source of living). In such situations, failures in agricultural development often lie at the heart of failures in overall development and the persistence of poverty (10). It follows that one of the main thrusts of national and international policies to solve the problem must be the promotion of local food production and broader agricultural and rural development in these countries, so as to simultaneously increase food supplies and stimulate overall development.

In conclusion, the widely held view that the persistence of food insecurity and undernutrition is not a problem of production (or production potential) but rather one of distribution (or access, or entitlements) can be both true and false at the same time. It is largely true if it refers to the world as a whole, but this is not a very helpful conclusion. It can be grossly misleading if it induces us to ignore the stark reality that it is often failures to develop agriculture and increase food production locally that lie at the heart of the local food insecurity problem. This is certainly not equivalent to saying that countries in that condition (undeveloped agriculture, often poor natural resource endowments, and large parts of their population dependent on them for a living) have the potential to develop toward middle-income status with an internationally competitive agricultural sector. It rather underscores the need for the path to less poverty, better food security, and eventually freedom from heavy economic dependence on poor agricultural resources to pass precisely through an initial phase of improved agricultural productivity (11).

What are the prospects that progress may be made in the foreseeable future (15–30 years)?

⁸Simpson's paradox, meaning that the world can get poorer on average even though everyone is getting richer, simply because the share of the poor in the total grows over time. This can be illustrated as follows (example based on approximate relative magnitudes for the developing and the developed countries): in a population of four persons, one is rich, consuming 625 kg of grain, and three are poor, each consuming 225 kg. Total consumption is 1,300 kg, and the overall average is 325 kg. Thirty years later, the poor have increased to five persons (high population growth rate of the poor) but they have also increased consumption to 265 kg each. There is still only one rich person (zero population growth rate of the rich), who continues to consume 625 kg. Aggregate consumption is 1,950 kg, and the average of all six persons works out to 325 kg, the same of 30 years earlier. Therefore, real progress has been made even though the average did not increase. Obviously, progress could have been made even if the world average had actually declined. Thus, if the consumption of the poor had increased to only 250 kg (rather than to 265), world aggregate consumption would have risen to 1,875 kg but the world average would have fallen to 312.5 kg.

⁹Thus, the European Union (E.U.) production of cereals fell from 191 million tons in the 3-year average of 1989–1991 to 178 million tons in 1993–1995, before growing again to 207–208 million tons in 1996 and 1997 following the high world market prices and the relaxation of supply controls. Production grew further in 1998 to an estimated 212 million tons.

Future Prospects

Demographics, Incomes, and Poverty. One of the key variables determining future outcomes, the growth rate of world population, has been on the decline since the second half of the 1960s. The U.N. demographic assessment of 1996 (12) has a medium variant projection indicating further deceleration, from 1.4% p.a. currently (1995–2000) to 1% p.a. in 2020 and to 0.4% p.a. by the middle of the next century.^{ll} However, the absolute increments in world population are currently very large, about 80 million persons p.a., over 90% of whom are added in the developing countries. Such high annual increments (in the range of 70–77 million in the new projections of 1998) may persist for another 15–20 years, but with declines in prospect for the longer term future, falling to some 40 million p.a. (30 million in the new projections) by 2050. Demographic growth in sub-Saharan Africa will increasingly dominate the total additions to world population: it will account for one half of the world increment by 2050, compared with only one fifth currently.

On the economic side, the most recent (December 1998) assessment of world economic growth prospects (13) implies that the rate of poverty reduction in the developing countries will be much slower compared with the past, when it was essentially fuelled by the rapid economic growth of East Asia. The growth of this region has been interrupted, and the average of the next 10 years (1998–2007) may be only 2.9% p.a. compared with 7.2% p.a. in the preceding 10 years (1988–1997) (in East Asia not including China; the fall is much less pronounced if China is included in the region, from 7.4% to 4.8%). On the other hand, South Asia may nearly maintain its past growth rate at the respectable level of 5.4%, a prospect that goes some way toward compensating the loss of poverty reduction momentum emanating from East Asia. At the other extreme, in sub-Saharan Africa, the growth rate of per person income is expected not to exceed 1.0% p.a. This outcome does not augur well for the reduction of poverty and hence undernutrition in the region, even if it reverses the trend of the negative growth rates of the past.

Food and Agriculture. These overall economic and demographic prospects form the background against which we must assess the prospects for future progress in food and agriculture. One can say right from the outset that the average world indicators of food availability will register only modest gains. This is because the overall demographic and economic outlook implies that the share of the poor, or rather those with lower-than-average food consumption levels, in the world population is set to continue rising. The food insecurity and undernutrition problems will persist, at somewhat attenuated levels, in the medium term future and perhaps well beyond, in many countries starting with very unfavorable initial conditions (mainly in sub-Saharan Africa and, to a smaller extent, in South Asia and selected countries in other regions). One does not need sophisticated analytics to prove this point: any country starting with per person food supplies of 2,000 kcal/day (and some countries start with less) and a population growth rate of 2.5–3.0% p.a. would need a growth rate of aggregate food demand of about 5% p.a. for 15 years if, by 2010, it were to have 2,700 kcal/day, a level usually associated with significantly reduced undernutrition (provided inequality

of distribution is not too high). Obviously, this kind of growth rates of aggregate demand for food can only occur in countries with “Asian-tiger” rates of economic growth sustained over decades. Few of today’s poorest countries with very low food consumption levels face such prospects. As noted, the recent crisis that hit several economies of East and Southeast Asia will also take its toll. The rapid pace of progress of the recent past, particularly in diet diversification toward livestock products, is being interrupted, and some countries (e.g., Indonesia) are suffering outright reversals.

These prospects, particularly the demographic ones, are somewhat different from those used some 5 years ago to produce the Food and Agriculture Organization’s assessment of world food and agriculture prospects to 2010, with particular reference to the developing countries, in the study “World Agriculture: Toward 2010” and subsequent modifications used in the technical documentation of the World Food Summit of 1996 (1, 14). However, the essence of our findings as concerns key variables of food security at the level of large country groups and the world as a whole remains largely valid.** The main findings, including selected preliminary findings from ongoing work to update the study and extend the time horizon to 2015 and 2030, are summarized below.

- The per person food availability of the developing countries as a whole will continue to increase from the current (1994–1996) 2,580 kcal/day to about 2,750 kcal/day by 2010. However, there will be only very modest gains in the currently very low average food availability of sub-Saharan Africa, whereas South Asia may still be in a middling position by 2010. The other developing regions, already starting from better levels now, are expected to be near, or above, 3,000 kcal/day.
- The per person consumption of cereals (all uses) of the developing countries may rise from the 245 kg of 1994–1996 to some 260 kg in 2010. The preliminary projections to 2030 suggest a further rise to about 280 kg, whereas the world average will likely reverse its trend toward decline and rise again—from the about 320 kg in the mid-1990s to about 340 kg in 2030. Important in this reversal will be, in addition to the rise of the developing country average, the change of two trends that in the past contributed to its decline: (i) the bottoming out of the declines and the eventual upturn of per person consumption in the formerly centrally planned economies; and (ii) a similar process (already under way) in Western Europe following the policy reforms that lowered domestic cereal prices and reestablished the competitiveness of cereals *vis-a-vis* cereal substitutes in the feeding of animals.
- The incidence of undernutrition in the developing countries may decline in relative terms (from 21% to 12% of the population) but, given population growth, there will be only modest declines in the numbers undernourished. The current level of over 800 million persons is expected to decline to about 680 million by 2010 (1). A high incidence of undernutrition will persist in sub-Saharan Africa, and a

^{ll}The 1996 medium variant projection was for world population to reach 9.4 billion by 2050, up from 5.7 billion in 1995. The just released new U.N. assessment of 1998 shows even more steep deceleration, leading to a world population of 8.9 billion in 2050, about 0.5 billion below that projected in 1996. However, over one half of this reduction (270 million) is in the projected population of sub-Saharan Africa, in part because of the revised estimates of the impact of the AIDS epidemic. As such, this further reduction in projected population is partly associated with negative rather than positive developments in human welfare.

**Subject to the great uncertainties concerning the prospects of sub-Saharan Africa, following the drastic revisions of the demographic data. For some countries, not only the projections but also the historical data were revised drastically. For example, in the base year data of the Food and Agriculture Organization Study (14), the 1990 population of Nigeria was given in the 1990 U.N. population assessment as 108.5 million. Four years later (in the 1994 assessment), the population for the same year was given as 96.2 million. The most recent (1998) assessment reduced the 1990 population further to 87 million. One can easily imagine what these revisions imply for the estimates of the key variable of per person food availability and the incidence of undernutrition, a variable which, at low levels of foods availability, is very sensitive to variations of even 5%. The implication is that we shall have to reevaluate where we stand now and where we stood in the past, before we can start talking about the future.

somewhat reduced one in South Asia. These two regions could account for 68% of the developing country total, up from 56% currently.

- Local production increases will be by far the main source of the growth in the food supplies of the developing countries. Their cereals production was projected to grow at 2.1% p.a. from the 3-year average 1988–1990 (the base year of the study) of 845 million tons to 1.32 billion tons in 2010 (wheat, rice in milled form, coarse grains). Nine years into the 21-year projection period, the production of the developing countries had risen to 1,015 million tons (3-year average for 1996–1998) and the growth rate from 1989 to 1998 was as projected, 2.1% p.a.
- As in the past, and moreso in the future, the mainstay of production increases will be the intensification of agriculture in the form of higher yields and more multiple cropping, particularly in the countries with appropriate agroecological environments and little or no potential to bring new land in cultivation. As far as possible, we projected yields of the developing countries (other than China) for several agroecological environments.^{††} The end result of the detailed projections (for individual countries and crops) indicates that the growth of the average yields of the developing countries (other than China) will be slower than in the past, 1.5% p.a. (from 1.9 tons/ha in 1988–1990 to 2.6 tons/ha in 2010; ref.13, p. 169), compared with 2.2% p.a. in the preceding 20 years (average yield of wheat, rice paddy, and coarse grains). Nine years into the projection period (1989–1998), the average cereal yield grew as predicted at 1.5% p.a., although rice yield grew by less than predicted, that of maize by more than predicted, and that of wheat as predicted. Continued growth of average yields, even at the lower rates projected here compared with the past, will not come about without effort. Growth in average yields will depend crucially on policies that attach high priority to efforts at agricultural research and technology development and diffusion, as well as on a more active role of the state in the areas of infrastructure, education, and the creation of conditions for markets to work.
- Land expansion will continue to be a significant factor in the growth of agriculture in those developing regions where the potential for expansion exists (many countries in sub-Saharan Africa and South America) and the prevailing farming systems and more general demographic and socio-economic conditions favor land expansion. It is estimated that the developing countries outside China have some 2.5 billion ha of land of varying qualities, which has potential for growing rainfed crops at yields above an “acceptable” minimum level. Of this land, some 720 million ha (plus another 36 million ha of desert land reclaimed through irrigation) are already in cultivation in the developing countries outside China (arable land and land in permanent crops). Most of the remaining 1.8 billion ha is in Latin America and sub-Saharan Africa. At the other extreme, there is virtually no spare land available for agricultural expansion in South Asia and the Near East/North Africa region. Even within the relatively land-abundant regions, there is great diversity among countries and subregions as concerns land availability per person, both quantity and quality. For example, in sub-Saharan Africa, land is scarce in East Africa, and land is relatively abundant in Central Africa. Land expansion may add some 90 million ha to the above estimates of cultivated land of the developing coun-

tries (other than China). Such expansion will account for about 20% of the increase in their aggregate crop production.

- These projections of areas and yields were arrived at through an examination of the agricultural growth needs and the potentials for land expansion and for technology development and adoption in each country. It would appear that the widely held view that land in agricultural use is not (or will not be) growing any more is probably unduly influenced by the experiences of the industrial countries, and indeed by that of their cereals sector in which area has been on the decline. As noted, this is not the case in those developing countries that combine the above-mentioned characteristics (availability of land, need to expand output and farming systems and, more general socioeconomic conditions favoring land expansion rather than intensification). Otherwise, why should we worry about tropical deforestation caused by, among other things, expansion of agriculture? What does the empirical evidence show? Unfortunately, the quality of the general land use data leaves much to be desired. The data of harvested, or sown, area for the major crops are comparatively more reliable. They show that expansion of harvested area continues to be an important source of agricultural growth in sub-Saharan Africa and South America. In these two regions, the harvested area under the major crops (cereals, oilseeds, pulses) grew 17% in the last 10 years (from average 1986–1988 to average 1996–1998). The comparable increase for the rest of the developing regions was 6%. Moreover, in sub-Saharan Africa and South America, the expansion of area under these crops is likely to have involved bringing new land in cultivation rather than increasing multiple cropping. The latter is not favored by the predominantly rain-fed character of their agriculture. The opposite is likely to have been the case in the other developing regions, where irrigation is very important.
- This projected increase of land in agricultural use (some 90 million ha, or 12%, in the developing countries as a whole, excluding China) is a small proportion of the total unused land with rain-fed crop production potential (some 1.8 billion ha). Naturally, such unused land should by no means be considered as a “reserve” for agricultural expansion. As far as we can tell (ref. 13, pp. 155–158), some 50% of it is under tropical forest, and large tracts are environmentally fragile or suffer from other constraints, including lack of infrastructure, incidence of disease, etc.
- Concerning the environmental and sustainability dimensions of the expansion and further intensification of agriculture, we note that (i) the foreseen land expansion need not be associated with the rapid rates of tropical deforestation observed in the past, although there is no guarantee that this will be so; (ii) there will be further increases in the use of agrochemicals (fertilizer, pesticides) in the developing countries, although at declining rates compared with the past; (iii) increased use of fertilizer is often indispensable for sustainability (to prevent soil mining); and (iv) the need to accept tradeoffs between production increases and the environment will continue to exist in the foreseeable future and the policy problem is how to achieve such increases while minimizing adverse impacts on natural resources and the wider environment.
- The net food imports of the developing countries from the rest of the world should continue to grow, although not at very high rates, i.e., we do not expect major structural surges in the demand for imports like those that occurred in the 1970s (see above). In an earlier version of the study completed in the mid-1980s with time horizon 2000 (15), we had projected net imports of cereals of the developing countries to grow to 112 million tons by the year 2000. The evolution to date indicates that the year 2000 outcome will likely be fairly close to this projection, because net imports have been

^{††}Problems with the land and yield data of China (3) made it necessary to project the country's production directly, not in terms of land-yield combinations as it was done for the other developing countries. The resulting projection of China's production of cereals implies a growth rate of 2.0% p.a. from 1988–1990 to 2010 (ref. 13, p.141). The actual outcome to 1998 has been 2.2% p.a.

in the range 100–110 million tons in recent years, whereas the current crisis affecting key developing countries does not augur well for an upturn in their import demand. It is expected that there will be some upswing in imports in the next decade, reaching 160 million tons by 2010.

- The rest of the world should face no major constraints in generating this additional export surplus of cereals, given that (i) the domestic demand of the main exporting countries grows very slowly and below the potential of their agriculture to increase output, and (ii) part of the additional import requirements of the developing countries is being offset by declining import demand of the region of Eastern Europe and former U.S.S.R. This latter region was a heavy net importer in the pre-reform period (some 35 million tons in 1989–1991), but may be a modest net exporter by 2010. The region's net imports had already been drastically reduced by the mid-1990s, whereas for the trade year July 1997–June 1998, the region is estimated to have been a net exporter of some 3.5 million tons. For the longer term, it is possible to visualize this region emerging as a major additional source of cereal export surpluses in the world (16), just as Western Europe did in the 1980s, although for very different reasons. In the case of the former centrally planned economies, an export surplus will likely be generated from the eventual recovery of agriculture from the status of near-collapse that accompanied radical systemic reforms, rather than from high agricultural support and protection of the type applied in Western Europe.
- For the longer term beyond 2010, the preliminary findings of the above-mentioned work to update the study and extend its time horizon to 2015 and 2030 indicate that the net cereals exports of the major exporters (North America, Western Europe, Australia, Argentina) would need to approximately double by 2030, from the mid-1990s level of 160 million tons. The required growth rate of their production for generating this export surplus and also meeting the growth of their own demand (including that part of their domestic demand for feed cereals going to produce more meat for export) would be around 1.1% p.a. in the 35 years from 1994–1996 to 2030. This growth rate is well below that achieved in the preceding 35 years (2.0% p.a. in 1961–1996). However, the growth rate of their combined production has been on the decline over time, from 2.8% p.a. in 1961–1986 to 1.2% p.a. in 1986–1996. As noted, this slowdown was mainly the result of lack of demand, falling real prices, and policies put in place to control the growth of production and avoid the accumulation of excessive surpluses.
- The prospect that the production growth rate in the exporting countries needs to be lower than in the past does not in itself guarantee that it is a feasible proposition. In particular, environmental concerns related to intensive agriculture in the high-income countries (nitrate pollution, soil erosion, perceived risks from genetically modified organisms, etc.) may contribute to slow the rate at which progress may be made in achieving the required yield increases. However, the environmental implications of increased production for export may appear in an entirely different light if examined in a global context, rather than solely in the context of the resource and environmental context of the exporting countries themselves. The global context is provided by the realization that major jumps in the absolute volume of world production are in prospect over the longer term, even if the growth rate of production will be lower than in the past. For example, in the case of cereals, we should be thinking in terms of world production growing from the 1.8 billion tons of the mid-1990s to about 2.9 billion tons by 2030 (5). Obviously, trade will contribute to spread the associated environmental pressures more evenly across the globe. This raises the issue of how trade and the distribution of environmental pressures over the globe are related. Will trade

help assign relatively more pressures to countries that can best respond to them, given their resource endowments and technological prowess?

- This issue can be addressed schematically with the aid of a simple taxonomy of the combinations of natural resources and technology used in production, on the one hand, and development levels, on the other (examples given in refs. 5 and 18). The former determines the extent to which the growth of production enhances the risk of adverse environmental impacts, whereas the latter is instrumental in determining the value people assign to resource conservation and the environment relative to the more conventional benefits from increased production, e.g., food security, farm incomes, and export earnings. Such a taxonomy can help put in a world context the environmental risks of more intensive grain production in the developed exporting countries and make it possible to compare them with those incurred by other countries that would also be raising their grain production. It will also provide useful information for judging the extent to which enhanced production for export in the developed countries may contribute to world food security by making world agriculture as a whole more sustainable, or less unsustainable—if one subscribed to the view that the ever-growing volume of overall economic activity is putting the world on an unsustainable path. This is not the place to develop this subject, but raising the issue is certainly an integral part of any debate concerning world food futures and the role of the different countries.

Conclusions

The fears of impending food crisis that dominated the thinking of some observers up to about mid-1997 have subsided following the reversal of the signals of scarcity (rising prices in world markets).^{‡‡} It is now well accepted that, at least over the medium term, there appear to be no major global constraints to expanding world food production at a rate sufficient to match the growth of the effective demand for food (see, for example, ref. 17). The deceleration over time of the effective demand for food contributes materially to this “happy” state of affairs. Such deceleration results from both positive and negative developments from the standpoint of human welfare. The positive ones are the slowdown in population growth because of reductions in fertility around the world and the fact that an ever-growing proportion of world population gradually achieves sufficient levels of nutrition beyond which there is only limited scope for further increases in per person food demand. The negative aspects are the contribution of higher mortality (than they would be otherwise—see footnote ||) to the slowing of global population growth, and the role of poverty in depressing demand for food. Demand for food is decelerating because a significant part of world population with still very inadequate consumption levels lacks purchasing power and has no way of expressing the need to increase consumption in the form of solvable demand in the marketplace. This is why the problems of food insecurity afflicting many countries and population groups remain as severe as ever, regardless that price trends in world markets indicate once again an overabundance of food relative to effective demand at the global level. World market prices do not reflect adequately the problems of the poor and the food insecure.

Our findings leave no scope for complacency concerning the prospects that progress during the period up to 2010, and perhaps also well beyond it, will be of a pace and pattern such as to eliminate, or significantly reduce, food insecurity. This is a pragmatic and far from optimistic assessment, even if those

^{‡‡}The latest (mid-December 1998) quote for wheat (U.S. No. 1 H.W., f.o.b. Gulf) is U.S. \$126/ton, compared with about U.S. \$210/ton in late 1996.

who think that the world is going to end tomorrow will find unduly optimistic any notion that further progress, slow and uneven as it may be, can be made.

The views expressed herein are the author's and not necessarily those of Food and Agriculture Organization. All data come from Food and Agriculture Organization's Faostat database (<http://apps.fao.org/cgi-bin/nph-db.pl>), except where otherwise indicated.

1. Food and Agriculture Organization (1996) *Food, Agriculture and Food Security: Developments Since the World Food Conference and Prospects*, Technical Background Document No. 1 for the World Food Summit (Food and Agriculture Organization, Rome).
2. Brown, L. (1995) *Who Will Feed China: Wake-up Call for a Small Planet* (Norton, New York).
3. Alexandratos, N. (1996) *Agric. Econ.* **15**, 1–16.
4. Alexandratos, N. & de Haen, H. (1995) *Food Policy* **20**, 359–366.
5. Alexandratos, N. & Bruinsma, J. (1998) in *Agriculture and World Trade Liberalisation: Socio-environmental Perspectives on the CAP*, eds. Redclift, M. R., Lekakis, J. & Zaniias, G. (CAB, Wallingford, U.K.).
6. Brown, L. (1996) *Tough Choices: Facing the Challenge of Food Scarcity* (Norton, New York).
7. World Bank (1997) *Commodity Markets and the Developing Countries* No. 4.
8. Johnson, D. G. (1999) *Proc. Natl. Acad. Sci. USA* **96**, 5915–5920.
9. Food and Agriculture Organization (1996) *Assessment of Feasible Progress in Food Security*, Technical Background Document No. 14 for the World Food Summit (Food and Agriculture Organization, Rome).
10. Mellor, J. W., ed. (1995) *Agriculture on the Road to Industrialization* (Johns Hopkins Univ. Press, Baltimore).
11. Lewis, W. A. (1953) *Report on Industrialization and the Gold Coast* (Govt. Printing Office, Accra, Gold Coast).
12. United Nations (1996) *World Population Prospects: The 1996 Revision* (United Nations, New York).
13. World Bank (1998) *Global Economic Prospects and the Developing Countries 1998/99: Beyond Financial Crisis* (World Bank, Washington, DC).
14. Alexandratos, N., ed. (1995) *World Agriculture: Toward 2010, an FAO Study* (Wiley, New York).
15. Alexandratos, N., ed. (1988) *World Agriculture: Toward 2000, an FAO Study* (New York Univ. Press, New York).
16. Dyson, T. (1996) *Population and Food: Global Trends and Future Prospects* (Routledge, London).
17. Ingco, M., Mitchell, D. & McCalla, A. (1996) *Global Food Supply Prospects*, World Bank Technical Paper 353 (World Bank, Washington, DC).
18. Food and Agriculture Organization Commodities and Trade Division (1996) *Environment, Sustainability and Trade Linkages for Basic Foodstuffs* (Food and Agriculture Organization, Rome).